

4th. With his eyes closed he cannot distinguish between a piece of modeller's wax, a piece of very hard wood, a large rubber tubing, and a folded and wrinkled newspaper, feeling no difference in resistance and not perceiving that he held anything in his hand.

This experiment appears very important to the authors as showing that the disappearance of the sensibility of the skin and of all the subjacent parts carries away also the feeling of resistance, that is to say, that form of muscular sense that has especially served the classical psychology to uphold its theory.

5th. His forearms were tied very tightly to a table so that he could not move them. He was then asked to fold his arms and to say when he had done this. He always thought that he had completely succeeded in folding them, whereas he moved them only slightly; his reason for thinking that he had accomplished the movement was because of the time that he had occupied. This last experiment is not cited as a proof of the non-existence of the muscular sense, since alone it is susceptible of two interpretations; but in view of the preceding experiments this interpretation is thought to be the only legitimate one. It is important to note that the statements of the patient himself show the importance of the notion of time in the appreciation of movements, since the indications furnished ordinarily by the sensations are lacking. These experiments are held by the authors, and with good grounds, to show that the disappearance of the superficial and deep sensibility carries with it the disappearance of the muscular sense, since, if he has still, with his eyes closed, some appreciation of movements, it is due especially to the knowledge of the time it takes to effect them, and perhaps also to an obscure consciousness of the modifications of respiration. If some movements may still be accomplished—and they can only be performed imperfectly when the sight does not direct them (*motor memory*)—this is due on the one hand to habit and on the other to the motor power of the images. The experiments add to the weight of cumulative evidence against the theory that the feeling of effort is due to a feeling of innervation ("*innervationsgefühl*"), and go to show that it is due to *afferent* sensations "coming from the tense muscles, the strained ligaments, squeezed joints, fixed chest, closed glottis, contracted brow, clinched jaws, etc." (Prof. James).

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The Muscular Sense; its Nature and Cortical Localization. By H. C. BASTIAN, M.D. (*Brain*, April, 1887).

The object of this long and exhaustive article, recently read before the Neurological Society of London, is to prove that the so-called motor centres of the cerebral cortex are in reality the cortical termini of muscular-sense impressions.

Starting from the proposition that all purposive movements are guided by sensations or by afferent impressions of some kind, the author proceeds to discuss these "kinæsthetic impressions." Impressions of various kinds combine for the perfection of a sense

of movement, viz., cutaneous impressions, impressions from muscles, and other deep textures of the limbs (such as fasciæ, tendons, and articular surfaces), all of which yield conscious impressions of various degrees of definiteness; whilst, in addition, there seems to be a highly important set of unfelt, or but little felt, impressions which guide the volitional activity of the brain, and which seem to bring it into relation with the different degrees of contraction of all the muscles that may be called into action. By means of these impressions we are made acquainted with the position and movements of our limbs, we are enabled to discriminate between different degrees of resistance and weight, and by means of them the brain derives much unconscious guidance in the performance of movements generally.

Kinæsthetic impressions are not instigators of movement in the same sense that visual or auditory impressions may be, but they are the guides of movement, and their guiding influence is brought to bear, partly under the form of actual sensations and partly under the form of revived impressions (the memories of past activity). It is these kinæsthetic impressions which awaken in consciousness the muscular sense.

The muscular sense may be impaired or lost by disease, and Bastian cites a number of cases of various kinds in which this loss has been a prominent symptom. In these cases, the common feature is an inability on the part of the patient to judge of the locality and position of his limb when his eyes are closed, or to execute voluntary movements with accuracy when not aided by sight. It occurs in locomotor ataxia and in some cases of cerebral hemianæsthesia. But Bastian calls attention to the well-known fact that the degree of disturbance of muscular sense in these diseases is independent of the degree of disturbance of tactile and painful sensations, and urges that this independence proves that these sensations are independent of one another and that the tracts by which they are transmitted are also distinct. He claims that we are ignorant of the course of these tracts, while those who are familiar with German and American literature will recollect that Kahler, in Prague, and Spitzka, in New York, as long ago as 1884 established independently the existence and situation of the muscular-sense tracts—a fact which was confirmed by a collection of cases published in this JOURNAL, in July, 1884, by the reviewer. But Bastian has also found a number of cases in which cortical disease has been attended by a loss of muscular sense, and since such disease corresponds in its course with diseases of the motor area, and since the lesions in these cases have been found in the motor area, he claims that the kinæsthetic impressions are received in this part of the brain. He then shows that such impressions may be revived in memory; in other words, that we possess memories of motion as well as of sensation—a fact which will be admitted at once by those who are familiar with Meynert's writings upon this subject, in which he constantly uses the term "*bewegungsvorstellungen*"—motor memories. In fact, much of this part of Bas-

tian's article coincides in a remarkable degree with the positions long ago advanced by Meynert, although no reference is made to the German author. Such a revival of a kinæsthetic impression he considers identical with the sense of effort. It is here that he comes in conflict with a different view. Wundt believes that "the strength of the sensation of effort is dependent only on the strength of the motive influence passing outward from the centre which sets on the innervation of the motor nerves." Bain holds that "the sensibility accompanying muscular movement coincides with the outgoing stream of motor energy, and does not, as in the case of pure sensation, result from an influence passing inwards by ingoing or sensory nerves;" and to this view Hughlings-Jackson adheres.

Bastian, however, believes that "the feeling of expended energy, by which we obtain our ideas of resistance and of an external world, is not contained, as we think, in the volitional act itself, but is derived from impressions emanating from the moving organs themselves during the actual accomplishment of movements." He cites Prof. Wm. James, of Harvard, in his support. In reply to the question as to the nature of our sensible perceptions of movement, James says: "I unhesitatingly answer, an aggregate of afferent feelings coming primarily from the contraction of muscles, the stretching of tendons, ligaments, and skin, and the rubbing and pressing of joints; and secondarily, from the eye, the ear, the skin, nose, or palate, any or all of which may be indirectly affected by the movement as it takes place in another part of the body. The only idea of a movement which we can possess is composed of images of these, its afferent effects. The degree of strength of our muscular contractions is completely revealed to us by afferent feelings coming from the muscles themselves and their insertions, from the vicinity of the joints, and from the general fixation of the larynx, chest, face, and body, in the phenomena of effort, objectively considered. When a certain degree of energy of contraction rather than another is thought of by us, this complex aggregate of afferent feelings, forming the material of our thought, renders absolutely precise and distinctive our mental image of the exact strength of movement to be made and the exact amount of resistance to be overcome."

All our knowledge of movement, therefore, comes to us through sensory centres, and motor ideas are not in any way connected with an efferent or outgoing current. It is these kinæsthetic centres which are located in the so-called motor area of the brain. The muscular sense presides over voluntary movements, but the co-ordination of the motion is wholly a matter of spinal-cord action. The movement depends on the spinal cord or subcortical centres, though its particular *qualities* of force, rapidity, duration, etc., are dependent upon the cerebral or volitional influence. The cerebrum may be said to exercise a kind of co-ordination—it co-ordinates or adapts the movements which are organically represented in the spinal cord so as to make them accord qualitatively with the aim conceived. But to do this, it must be instructed from

moment to moment as to the exact nature of the movement actually produced, and this it gets from sight, touch, and the muscular sense. When movements are complex, long practice is needed to acquire the kinæsthetic impressions necessary, as in learning to play on an instrument.

Thus the performance of a voluntary act is always preceded by an idea or conception of the movement we desire to execute; and this idea or conception is for ordinary movements compounded of two kinds of past impressions, namely, those of the visual sense and those of the kinæsthetic sense. It is an error to look for special motor centres for the production of voluntary movements of any kind, either in the cortex or elsewhere. Ferrier's so-called "motor centres" are in reality kinæsthetic centres in which "muscular-sense" impressions in particular have been registered. As to the objection that from these centres the pyramidal tract proceeds which degenerates downward, Bastian replies that the pyramidal tract is doubtless efferent; but this fact does not at all touch the question whether the ganglion-cells which exercise a trophic influence on such efferent fibres constitute parts of sensory or of motor centres. The sensory incitations to movement constituting part of the volitional act must pass off from certain cortical areas in a definite and orderly manner, in order to excite motor centres, wherever they may be situated, and these pass along the pyramidal tract.

It may seem of little importance whether the Rolandic area is called a "motor area" or not, especially as Bastian admits that from it issue volitional motor incitations. But this he denies, for he says we should not call a cortical centre for afferent impressions motor any more than we should call the cell-nuclei on the sensory side of a spinal reflex arc "motor;" and again, the retention of such nomenclature tends to foster such false notions as that in the sense of movement we have to do with a so-called active sense differing from other modes of sensibility, and that we have such things as "motor ideas."

For these reasons, it seems necessary to Bastian to admit that the excitable areas in the Rolandic and marginal regions of the cortex are in no proper sense of the term "motor centres," and that the evidence at present in our possession makes it extremely probable that they are termini for kinæsthetic impressions derived from muscles, so that their excitation in this or that region is the immediate precursor of this or that kind of voluntary movement.

The article is one which does not admit of condensation and should be carefully read by those interested in the subject. The discussion of it before the Society was participated in by Drs. Ferrier, Sully, Ross, Crichton-Brown, Horsley, Haycraft, Mercier, and De Watteville, and elicited a number of varying views as to the relations of the muscular sense and of effort to volitional movement and its mechanism.

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